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Food Preservation and Its Contribution to Nutrition

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Food Preservation and Its Contribution to Nutrition

By WILLIAM B. ESSELEN*

Introduction

The impact of food processing methods on the future of our nutritional status is a timely and thought-provoking subject. It is stimulated by the many developments going on in the field of food production, processing and preservation as well as the continuing flow of reports on new nutritional findings from our research laboratories. Much of this research is being carried on by the food industries themselves or is supported by them.

As reported in our technical and lay publications, the picture of the future may appear confused and contradictory. On the one hand we read of the use of such devices at atomic radiation and added chemicals and antibiotics as methods of retaining the original freshness and natural characteristics of foods. On the other hand, we are faced with the specters of such things as harmful spray residues, possible toxicity of food additives, carcinogenic food colors and the dangers of fad reducing diets. Unfortunately a sound but modest interpretation of what these things mean in terms of our future nutrition is often lost behind the more spectacular aspects. Improvements and advances in nutrition do not ordinarily receive their due in terms of publicity and glamor. Fortunately improvements in the nutritive value of foods seem to closely parallel improvements in such attributes as color, flavor, texture and retention of freshness — the latter being the more obvious goal of current and future developments in food preservation methods. The future of our nutritional wellbeing, as influenced by advances in food preservation, is bright.

Research and development in this area by the food industry attests to the efforts being made to meet the needs and desires of the consuming public for quality, variety, and convenience in foods. A survey made by the National Research Council shows that in 1930 food companies in the United States employed only about 500 research staff members in all; and most of these individuals worked on short-range projects. This number rose to 2,800 in 1940, to 5,800 in 1950, and to 6,400 in 1951. This expansion has been matched by the complexity of the subject matter under investigation. Basic principles of nutrition, biochemistry and public health are explored in parallel with biochemical engineering to make available an abundant supply of superior products for the consumer. As the science of nutrition has grown, the complexity of food manufacturing and

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distribution has expanded to include long range planning for high quality farm crops, processing under precision control, and full cooperation with the public to assure protection of the consumer's health.

The food industries' broad and basic interest in nutrition research is illustrated by the programs sponsored through the numerous industry-wide supported institutes and associations. Further evidence of this community of interest was the establishment of the Nutrition Foundation in 1941 by food and related manufacturers. This organization was created as an expression of their interest in scientific progress and human health. The basic purposes of the Foundation are: (a) the development of a comprehensive program of fundamental research, providing basic information in the science of nutrition; and (b) the support of educational measures that will assist in making the science of nutrition effective in the lives of present and future generations. The entire program is one of public service. The funds of the Foundation are obtained through voluntary contributions from members and donors.

The following paragraphs attempt to describe briefly some of the major areas of research activity related to food preservation.

Cold Storage

Although the use of low temperature as a means of food preservation is not new, some of its potentialities are just beginning to be appreciated. Probably the principal use of cold storage for preservation has been as a means of retarding microbial growth and subsequent spoilage. In lieu of cold storage, foods have been canned, or sterilized within the container, or have been dehydrated to reduce their moisture level below that at which microorganisms can grow. These latter preservation methods have been generally considered as being sufficient unto themselves. That such is not necessarily the case is apparent upon a consideration of the nature of other deleterious changes such as losses of color, flavor, and nutrients during storage. Such losses of quality are chemical in nature and as such are affected by the well known influence of temperature on reaction rates. It is well known that certain heat labile nutrients, colors and flavors in foods are subject to thermal destruction during canning, drying and other cooking procedures. However, relatively little attention has been given to the fact that these same destructive reactions also go on, but at a slower rate, at ordinary storage temperature. These considerations serve to point out that we should recognize that such changes may occur, and that all foods, no matter how preserved, have certain unstable characteristics so far as storage-life is concerned. Storage life and quality retention are enhanced by storage at lower temperatures. Thus, for optimum quality retention, including nutrients, cold storage should be considered as an important supplement to other methods of preservation designed primarily to prevent microbiological spoilage.

The importance of temperature in the storage and warehousing of canned foods has been reviewed by Murray (1). Although the beneficial effects of

reduced temperatures have been recognized for a long time, only a limited amount of quantitative data is available. As Murray points out, the chemical reactions which bring about changes in canned foods during storage are extremely complicated, but the principle applies that as the temperature rises, the speed of the reaction increases. It has long been known as an empirical fact that many reactions approximately double or treble their velocity for an 18° F. temperature rise. The importance of this influence of temperature is evident when one considers the many ways by which chemical reactions may alter the flavor, texture, and nutritive value of canned foods. For example, a chemical reaction which occurs during 50° F. storage may theoretically take place twice as rapidly at 68° F. and four times as rapidly at 86° F. Storage temperature as a factor in preserving the nutritive value of canned foods was recognized in the extensive nutrition program carried out by the National Canners Association and the Can Manufacturers Institute in the 1940's. It was observed that the nutritive value of canned foods is maintained satisfactorily providing the storage temperatures are not excessively high. Storage temperatures between freezing and 50° F. were considered optimum for preserving the vitamin content of canned foods, while at temperatures above 90° F. a rapid destruction of many of the vitamins originally present in the product occurs. Controlled laboratory experiments showed that the retention of vitamins could be predicted with reasonable accuracy. In practice fair agreement existed between predicted and observed vitamin retentions.

Brenner, Wodicka, and Dunlop (2) and Freed, Brenner, and Wodicka (3) studied the effect of high temperature storage on the retention of nutrients in canned foods. At 90° and 100° F. storage there was a linear relationship between the log percent retention of thiamine and ascorbic acid and the length of storage. The destruction of these two vitamins proceeded according to a first order reaction as previously indicated by Wodicka (4). Storage studies on canned apricots, orange juice, peas, spinach, green beans and lima beans stored at 70°, 90°, and 100° F. showed that the classical arrhenius equation was applicable. That is, as a close approximation, the logarithm of the retention and therefore the log of the storage life of a given vitamin were linearly related to the temperature. These data were used and applied as a basis for (a) predicting the stability of ascorbic acid and thiamin at storage temperatures and times outside the range originally studied, including variable temperatures; (b) estimating the limits of temperature and time at or below which a given retention (or better) of the nutrient in question may be obtained; and (c) predicting the stability of these nutrients in other foods. It was found that such an approach was generally applicable.

It is also generally recognized that such quality factors as texture, flavor, and color are related to storage temperatures as are the labile nutrients such as ascorbic acid and thiamine. The relation of flavor retention to storage temperature in canned single strength orange juice provides an excellent example of the importance of low temperatures in maintaining quality. A number of research

papers have demonstrated this fact. A recent report by Guyer and Boyd (5) showed that the flavor of canned orange juice stored at room temperature deteriorated rapidly from a rating of good, one month after packing, to a rating of poor to extremely poor, at the end of nine months. No significant difference was noted between the flavor of a juice stored at –10° F. and 35° F. However, in both cases there was a gradual deterioration of the flavor over a twelve-month storage period from very good to slightly above average. Some years ago storage studies on can and glass packed single strength grapefruit and orange juices carried on at our laboratory demonstrated the importance of storage temperatures even a little below room temperature on flavor and ascorbic acid retention. While these juices stored at room temperature showed definite flavor deterioration after 6 to 9 months and a marked loss of quality at 12 months, the quality was well retained during storage at 50° to 58° F. even up to two years. The juices stored at 35° F. showed only a slight loss of quality after two years.

Available information indicates a similar influence of storage temperature on the retention of nutrients and quality of foods preserved by dehydration and those preserved in the fresh or raw state, such as fresh produce. For example, Beardsley, Prindle and Stevens (6) and Neuman, W. K., Wilson, R. V., and Van Wazer, F. P., Jr. (7) demonstrated the deleterious effects of high storage temperature on nutrient and quality retention in dehydrated vegetables.

Work carried on and sponsored by the Quartermaster Food and Container Institute for the Armed Forces has provided important contributions in the recognition of the importance of low storage temperature for retention of quality in foods. While this work has been rather directly concerned with rations and foods for the Armed Forces it is also applicable to our civilian food supply. These studies on the effect of temperature on the rates of deterioration of canned and dehydrated foods have been reviewed by Mitchell (8). Storage at 40° F. held changes of all types in most products to a negligible value. At 70° F. deteriorative changes took place at rates which varied with the food itself. Most items were still usable after two years' storage at this temperature, but some of them showed a loss from the initial high quality. Between 70° and 100° F. pronounced deterioration took place, resulting in the majority of products becoming unfit for use with six to 18 months of storage at 100° F. It was concluded that in general the foods kept three to four times longer at 70° F. than at 100° F. It was further indicated that the majority of these same products would keep in good condition for at least five years at 40° F. or lower.

Application of these recognized principles should and will be an increasingly important adjunct to our food preservation methods of the future. Except for frozen foods themselves, cold storage for many foods preserved by other methods can be a valuable means of enhancing the stability of overall quality and nutritive value. Different foods vary in their stability at warm temperatures and as we learn more about the reaction rates of their labile constituents we will be better able to prescribe storage temperatures for them. As will be discussed presently

some of the new developments in preservation methods, such as aseptic canning and radiation sterilization have as their objective the maximum retention of the fresh characteristics of the product in question. If we are successful in approaching these goals in the basic preservation methods, efforts should certainly be made to retain the original quality of the processed foods during subsequent storage. At present there is considerable interest in extending the use of cool storage for many products that are now handled under normal or ambient temperature storage conditions. Such changes naturally present economic considerations which must be reconciled with the benefits to be derived. However, as these factors are worked out they will contribute to a better quality and nutritive value of our food supplies.

Freezing

It was less than 30 years ago that frozen foods, as we ordinarily think of them, were introduced on the market. Although probably most of us still think of frozen foods as "new" products, our college students of today think of them as something that was devoloped in the dim past. After a somewhat slow start, when first placed on sale in Springfield, Massachusetts, frozen foods over a short span of years have assumed an important position in our diet. Today more than five hundred varieties of packaged frozen foods are on the market. Among these one may select complete turkey dinners with all the fixings, ready-to-serve in the package with a little heating, all kinds of meat and chicken pies, tuna pies, frog legs, chicken a la king, breaded veal cutlets, breaded shrimp, spaghetti sauce, crab meat au gratin, Chinese dishes, pizza pies, cheese cake, French fried potatoes, waffles — even frozen bread and rolls, to say nothing of the usual fruits, concentrated fruit juices, fish, meat, poultry and vegetables.

From the foregoing discussion on cold storage, it is obvious that the color, flavor and nutrients of foods should be well retained during freezing and frozen storage. This was substantiated in the early days of freezing by extensive work carried on and supported by Birdseye Frozen Foods. Recently, an extensive research project on the nutritive value of frozen foods was sponsored by the National Association of Frozen Food Packers (9). Eight vitamins, six minerals, and proximate composition were determined on composites of 796 sets of samples representing 1953 and 1954 production seasons for 14 frozen fruits, 7 frozen juices, and 30 frozen vegetables in the continental United States and Hawaii. Packages were taken from commercial processing lines of more than 150 freezing plants in all production areas. Substantial amounts of ascorbic acid were found in all citrus juices, in practically all fruits, and in most vegetable products. Many of the products contained low levels of sodium.

The importance of temperature during frozen storage on the retention of quality of frozen foods has been the concern of a number of investigators. Storage at temperatures no higher than 0° F. and preferably lower, such as −10° F. is often considered to be the recommended upper limit so far as tempera-

ture is concerned. Guerrant (10) has reported a recent study on changes in color and ascorbic acid of foods during frozen storage. With frozen fruits and vegetables stored at +10°, 0°, and –20° F. for twelve months, it was found that storage temperature had a very definite effect on the capacity of the foods to reflect visible light (an indication of color) and on their reduced ascorbic acid content. The greatest change in reflectance and in vitamin content occurred in foods that had been stored at the higher temperatures. Changes in the reflectance (or color) of the foods during frozen storage seemed to parallel changes in ascorbic acid content. The data presented point to the importance of maintaining frozen foods at temperatures below 0° F. during storage and in distribution channels.

From a standpoint of improved nutrition, we must consider more than the nutritive value of the frozen foods themselves, particularly in the case of the so-called precooked or ready-to-serve products. Why are these foods receiving such widespread public acceptance? This question has been answered, at least in part, in a recent discussion on "Revolution in the Kitchen" by W. B. Murphy, President of the Campbell Soup Company (11). In referring to present trends in packaged and convenience foods and why people want them, Mr. Murphy said, "To save trouble. The average housewife isn't interested in making a slave of herself. When you do it day after day, it tends to get a little tiresome, and the young housewife is really less interested in her reputation as a home cook today. She used to feel it was her duty to do all this home work, and she's lost some of that. She's interested in nutrition, in food values, and in her family's health and happiness. She doesn't regard slaving in the kitchen as an essential of a good wife and mother. She'll slave if necessary, but not if someone else will do the hard work and deliver value." Another factor to consider is that many more women are working today than before World War II, particularly in many of our thickly settled and industrialized urban areas. For many such working wives, convenience foods provide variety and more nutritious meals for the family than would otherwise be available.

It has been estimated that today an average woman spends approximately one and one-half hours preparing the daily food and meals for a family of four whereas thirty years ago, she spent about five and one-half hours at this task. A recent study made by the Department of Agriculture showed that ready-to-serve frozen foods save the average homemaker about five-sevenths of the time she would normally spend preparing foods in her own kitchen. Thus, in view of our changing method of living as brought about by social and economic influences, it is inevitable that readily prepared, attractive, tasty and nutritious foods are coming to play an increasingly important role in our diet. The variety provided by such products cannot help but upgrade our nutritive intake — with all due respect to the bread and jam or meat and potato repast of yesteryear.

Dehydro-freezing or freeze-drying is a relatively new processing method proposed by investigators at the Western Utilization Research Branch of the

U. S. Department of Agriculture. In this process, approximately 50 percent of the moisture is removed from foods by dehydration, after which the product is frozen. Tests have shown that dehydro-freezing is very effective in retaining the flavor, color, vitamins and other desirable characteristics of the product. In addition, the weight loss could result in substantial freight cost savings and economy of frozen storage space.

A review of developments in frozen foods would not be complete without mentioning frozen concentrated citrus juices. Since being introduced in 1946, their production and consumption has exhibited a growth of over 5,000 per cent. This phenomenal development has revolutionized our fruit juice drinking habits. Developments in the handling of citrus juices are still going on. Fresh orange juice prepared in Florida is now being shipped, under refrigeration, to metropolitan areas where it is distributed by dairies along with their milk deliveries. Within recent months such freshly expressed juice has been shipped north by ocean going tanker equipped with stainless steel refrigerated tanks.

Heat Processed Foods

Recognition of the nutritive value of commercially canned and frozen foods is another milestone in the acceptance of these products. As a result of extensive nutritional investigations on these foods, we have come to appreciate their nutritional value. This information was effectively presented to the public in a popular consumer article in the September 1954 issue of McCall's Magazine by Dr. Frederick Stare of the Department of Nutrition at the Harvard School of Public Health. According to Dr. Stare, "Modern canned and frozen foods are picked at the precise moment of ripeness, then quickly and carefully processed. This way canned and frozen foods contain essentially the same food values as fresh produce. . . . Much of the produce offered to us in the market is over a week old and has journeyed hundreds of miles before it appears on grocery store counters. Thanks to modern transportation and refrigeration, it is still nutritious and tasty, but fresh fruits and vegetables are not superior in food value to commercially canned and frozen foods."

During the past decade important progress has been made in developing canning procedures which provide a marked improvement in the quality of canned foods. For some time it has been recognized that the factors of quality in canned foods such as color, flavor, texture, and vitamin content are most efficiently preserved by high temperature-short time processing.

It is generally considered that the rate of destruction of bacteria increases tenfold for each 18° F. rise in processing temperature, while the chemical reaction rates responsible for product deterioration are only doubled. Thus, processes of equivalent sterilizing value for shorter times at higher temperature effect a greater retention of the natural characteristics of the product being canned. Methods are being developed and improved for the practical application of these principles by: (a) "flash" sterilization of liquid and semi-liquid products

followed by aseptic filling and sealing in sterile containers, or (b) agitating or induced convection heating of liquid and semi-liquid products within the container. In experimental tests and in practice it has been found that such methods of processing greatly enhanced the retention of thiamine with an accompanying marked improvement in quality. Work carried on in our laboratory (12) with strained foods showed that in general, products processed by high-temperature-short-time methods showed better color and thiamine retention, and initially higher pH values than control samples processed in a conventional retort. Initial color and thiamine retention advantages were maintained over extended storage periods. Flavor differences were largely marginal for most products, although in some instances, HTST vegetable samples were described as having a "raw" or "fresh" taste. We have also investigated the rate of destruction of thiamine in aqueous solution, phosphate buffered solutions and low acid foods over the temperature range of 228° to 300° F. (Feliciotti and Esselen, (13). It was found that thiamine in foods is more resistant to thermal breakdown than is the pure vitamin in aqueous or buffered solutions. The variation was independent of differences in pH since solutions of similar pH to that of specific foods showed more rapid destructive characteristics. It was suggested that the thermal destruction of thiamine in foods may be dependent on the interrelationship of pH and the relative proportions of the free and combined forms of the vitamin. At a given pH level the rate of destruction of thiamine increased with increasing content of the combined forms. Carrots, green beans, peas and pork showed similar thermal destruction characteristics for thiamine. The thermal destruction of thiamine in spinach, beaf heart, beef liver, and lamb was more rapid than in the former four products.

Among the products which have been found definitely improved by these newer canning methods are whole grain corn, pureed and strained meats and vegetables, certain concentrated and creamed soups, a number of milk products and many vegetables. Such technological developments point the way to a new era in heat processed foods that are of improved quality and nutritive value.

The question is sometimes asked if the rapid increase in frozen foods has not affected the production of canned foods. Available evidence would indicate that frozen foods are supplementing rather than replacing most canned foods. Furthermore, there are some products that are better heat processed than frozen, such as pork and beans, a number of tomato products, etc.

Before leaving the subject of heat processed foods, mention should be made of developments in electronic processing, such as microwave and induction heating and sterilization. There is an interest in application of this type of heating for the sterilization of foods. To date there is little or no information available on the influence of such processing methods on the nutritive value of foods. However, experience would suggest that nutrient retention and overall quality would be enhanced as heating and cooling times are decreased.

Radiation Sterilization

The use of ionizing radiation, as in the form of cathode and gamma rays for the preservation of foods is one of our newer and much publicized methods. A tremendous amount of research has been carried on in this area during the past few years, particularly under the sponsorship of the Quartermaster Food and Container Institute for the Armed Forces. The possibility of preserving foods without the use of heat has met with an enthusiastic response. However, the results obtained to date have shown that many problems accompany the application of this method of food preservation and that it may be some time before its use becomes widespread. The use of lower doses of radiation to "'pasteurize" rather than sterilize, and thus prolong the refrigerated storage life of certain foods such as meats appears to have many interesting possibilities. A comprehensive review of this subject up to 1951 was presented by Proctor and Goldblith (14). A more recent review was published last year by Hannan (15). Hannan has pointed out that the total amount of chemical change which occurs in an irradiated system is limited and, with a dose of 2,000,000 rep, is of the order of a few micro-moles per gram. In a foodstuff consisting mainly of water, however, most of the reactions which occur are typical "indirect" reactions and if one of the constituents is particularly radio-sensitive it may suffer a large proportion of the total change. If this constituent is present in large amounts, the percentage loss is rarely significant, but with trace constituents, such as the vitamins, it may represent an appreciable destruction. Published data indicate that a number of the vitamins are susceptible to irradiation, particularly when irradiated in pure solution. However, in intact foods less vitamin loss seems to occur. It has been suggested that in foods the vitamins may be protected, at least in part, by the presence of other components. Changes in amino acids, proteins, and carbohydrates by irradiation have been reported. According to Schweigert (16), from a biochemical and nutritional standpoint there are several major problems requiring extensive research: (a) detection and prevention of off-odors, flavors, and discoloration; (b) changes brought about by enzymatic activity and nonenzymatic activity during storage and distribution of the irradiated products; and (c) extensive studies to ascertain the effects of irradiation on the nutritive value of the foods as well as the wholesomeness of the products. Extensive programs of research are in progress and should eventually provide answers to some of these questions. An appreciation of the fact that probably not more than 0.003 per cent of the chemical bonds would be broken by the use of sterilization doses of radiation points to the difficulties involved in assessing the nature of the chemical reactions involved. According to the above author, prolonging the shelf-life of prepackaged foods, such as meat, by low level irradiation appears to offer more promise than do actual sterilization treatments.

Nickerson, Proctor, and Goldblith (17) have recently reported on the effect on organoleptic properties of certain food products of treatment with high voltage cathode rays. "Commercial" sterilizing doses of radiation for the foods

were found to lie in the range of 1.5×10^6 rep to 2.0×10^6 rep. They concluded that it was probable that the following vegetables could be irradiated at levels sufficient to provide commercial sterility without the development of unacceptable irradiation flavors: green beans, brussel sprouts, and sweet potatoes. Halibut and fishcakes were not affected in flavor by irradiation doses necessary to prevent spoilage at 37° C. Most of the ascorbic acid in asparagus was destroyed by the irradiation while only slight losses were encountered in broccoli and spinach. Irradiation of vegetables while vacuum packed or frozen prevented losses in chlorophyll to a significant extent. According to Morgan (18) irradiation can find its place in the food preservation field in terms of (a) total sterilization of products or (b) "pasteurization," i.e., partially decreasing the microbial population, utilizing refrigeration, sprout inhibition, and various other applications as supplemental methods. Peas, green beans, broccoli, carrots, spinach, asparagus, sweet potatoes, and tomatoes appear to merit intensive development in terms of total sterilization, as do some pork products, fowl, and fish. A large number of formulated foods also should bear rigid examination in terms of future potential. Typical of these are baked beans, apple sauce, and baked products. A large number of foods, including beef products and cole slaw, appear highly promising for a process involving post-irradiation—irradiation plus refrigeration to extend shelf-life. Sprout inhibition of potatoes, onions, and other tubers appears promising. Other uses might be to effect a slight delay in the ripening rate of fruits and vegetables. Certain foods offer only limited, if any, hope for this type of process. Dairy products, in general, are sensitive to sterilizing irradiation, and certain fruits and vegetables with fragile structure, e.g., lettuce, appear limited in use due to their characteristic crispness and high moisture content.

The possible toxicity of irradiated foods has been of concern to those interested in this method of preservation. Extensive toxicity and feeding tests have been and are being conducted to provide an answer to this question. On the basis of available information, it would appear that radiation sterilization does not markedly impair the nutritive value of foods or produce toxic substances in them.

As yet, it is too early to properly assess the role of irradiation as a method of food preservation in the future, and its subsequent effect on our overall nutritional well being. However, where irradiation can be used in preserving and conserving foodstuffs it will make its contribution to our better nutrition. It may well be that as time goes on irradiation will permit the more widespread production and distribution of foods now considered perishable, and of new products to add variety to our diet.

Dehydration

Dehydration, one of man's oldest methods of food preservation, is taking on a new and important role. To many people the term dehydration implies dried vegetables and such items as were produced under wartime conditions and in which the quality was somewhat less than perfection. However, as an outgrowth

of developments during and after World War II, dehydration is proving the basis for a rapidly expanding line of convenience items. We are all familiar with the almost unprecedented consumer acceptance of such products as powdered beverages, cake and dessert mixes, milk drinks, and dried soups. For example, when cake mixes were introduced after World War II, they caught on immediately and joined the parade toward even greater consumer convenience. Sales soared twelvefold in the past eight years, turning such mixes into a $225 million a year business.

From the standpoint of the nutritionist, developments in dehydrated dairy products are particularly significant. The importance of these developments has been reviewed by Heineman and Wagner (19). Nonfat dry milk solids or "instant" dry milk, produced by a dehydration process based on an alteration of the degree of hydration of alpha lactose, retains all of the proteins, minerals, and B vitamins of milk. With our present mode of living requiring a lower daily caloric intake yet a high level of protective foods, nonfat dry milk fits admirably into the desired pattern. It also makes milk nutrients obtainable in areas where the milk supply was previously limited, or where economic conditions place a generous supply of milk nutrients out of reach of a large number of homes. It is one of the most flexible food items available to achieve higher levels of essential nutrients in the normal diet as well as a means of providing extra amounts of these nutrients in therapeutic diets.

The nutritive value of dehydrated foods, as we know them today, is well retained during processing and during storage too, if care is taken to avoid high storage temperatures. Such products also lend themselves to fortification or enrichment with added nutrients.

Preservation by Antibiotics and Chemicals

The application of antibiotics and chemicals occupies an important place in developments in food preservation today and in the future. Salt, acid, and sugar have been recognized and used for years in various roles as food preservatives. Likewise, sodium benzoate is a well known preservative. More recently sorbic acid has come into the picture as a preservative and has found important applications. So far as we know, these substances have little or no effect on the nutritive value of foods. Sulfur dioxide, a well known preservative, enzyme inhibitor, and anti-browning agent has also been widely used, particularly in the treating of dried fruits and vegetables. More recently this chemical has been used to prevent discoloration in prepeeled potatoes. Objections to the use of sulfur dioxide are that many people are sensitive to its taste, even in low concentrations, and it also is destructive to the thiamine in foods. Much effort has been expended in trying to find a good substitute for sulfur dioxide but with only limited success. Ascorbic acid is a very effective antioxidant for many applications. With this compound any residue over and above that required for its antioxidant functions serves to provide added vitamin C in the product.

The epoxides, ethylene and propylene oxide have been used to some extent, especially in dried foods. Research reported during the past two years has indicated that at least under some conditions, epoxides may cause a reduction in the nutritive value of foods. The actual nature of the reactions involved and their significance in practice remained to be clarified.

The use of antibiotics to retard and prevent spoilage in foods and to reduce the heat treatment necessary in processing canned foods is a field of active research and will undoubtedly become increasingly important in the future. If and when satisfactory uses of antibiotics are developed for reducing the heat process requirements of canned foods, the resulting products should exhibit a better retention of nutrients and fresh quality characteristics. More immediate applications of antibiotics appear to be as agents to retard spoilage in refrigerated fresh products such as prepackaged vegetables, fish, meat, and poultry. Tarr and associates at the Fisheries Technological Station, Vancouver, British Columbia have done much pioneer work in this field, especially in regard to the preservation of fish. Tetracycline compounds are already being used in this country to improve the keeping quality of fresh poultry and are also allowed in Canada in fish.

According to Miller (20) chlortetracycline is one of our first broad-spectrum antibiotics and is so called because such compounds are effective against a wide variety of bacteria. Under the Food and Drug Administration a tolerance of 7 p.p.m. has been established for residues of chlortetracycline in or on uncooked poultry. This amount is destroyed when poultry is cooked. Ten p.p.m. is recommended in the poultry dipping bath. Freshness in packaged poultry is maintained 2 to 3 times as long when treated with this compound. It also protects frozen poultry during and after thawing. The safety of chlortetracycline is well established by animal and human feeding tests. With fresh fish chlortetracycline extends the shelf life about one week when packed in antibiotic ice. Nearly all spoilage organisms in fish appear to be sensitive to chlortetracycline. In the case of red meat, this antibiotic is effective in treating beef carcasses. With some vegetables and fruits for freezing and canning aureomycin is effective in retaining quality and extra freshness up to the time of actual canning or freezing.

Wrenshall and McMahan (21) have described the merits of oxytetracycline, a second broad-spectrum antibiotic approved by the Food and Drug Adminstration, for poultry processing. It was reported that such antibiotics plus refrigeration appear to both: (a) cut down the initial population of bacteria that are capable of reproducing and (b) slow down the average rate of growth. The effects of refrigeration and antibiotics appear to supplement each other. In fresh vegetables treatment with the antibiotic was found substantially to extend the shelf-life of peas, broccoli, lima beans, cauliflower and spinach.

An important and expanding future may be forecast for the use of antibiotics by the food industry.

1. With poultry, meats, seafood and vegetables there is the possibility of a complementary action of irradiation and antibiotics in prolonging the shelf-life of refrigerated and prepackaged products.
2. Antibiotics can effectively supplement — but not replace — conventional food preservation techniques. Their effect is greatly increased when used in conjunction with refrigeration.
3. Antibiotics are not substitutes for proper sanitation and good processing methods.
4. Shelf-life of poultry, meat, ground sausage and cured and smoked ham can be markedly increased.

Among governmental and health agencies responsible for the wholesomeness of foods, there has been considerable concern regarding the possible toxicity of added preservatives. Stringent safeguards are set up to require extensive testing demonstrating the non-toxicity of such products before their introduction into foods. In the case of antibiotics, concern is felt lest the ingestion of such materials in the form of food preservatives lead to their accumulation in the body with the development of an immunity and sensitivity so that when such compounds are taken for therapeutic and medical purposes their effectiveness may be reduced. Present philosophy dictates the use of heat labile antibiotics which would be completely destroyed by cooking and heating before the food is eaten.

On the basis of available information, it would appear that the nutritive value of foods preserved by chemicals and antibiotics would be retained or enhanced in parallel with the retention of freshness. From a long range standpoint and a better knowledge of our nutrient intake, research on the effect of these new and future food preservatives on nutrient retention in foods is indicated.

Fortified and Dietetic Foods

This discussion would not be complete without a consideration of the future of fortified, enriched and dietetic or special purpose foods. Trends toward an increased use of special dietetic foods, particularly those with low sodium content, increasing use of synthetic sweeteners, low-fat dairy products and the possibility of supplementing the protein or amino acid content of cereals are all factors affecting or which may affect food processing and preservation methods of the future. A new and expanding knowledge of nutrition and the nutritional aspects of disease will lead to a better understanding of food composition and the need for its improvement for better nutrition. Problems of old age and geriatric foods are becoming increasingly important. The importance of amino acid deficiencies and imbalance is receiving increased recognition and will point the way towards improving protein quality by the addition of needed amino acids.

SUMMARY

Present developments in food preservation methods — freezing and refrigeration, dehydration, and preservation by heat, high energy, and by chemicals and antibiotics — have as a common goal the better and more economical retention of quality, either natural or added, of the finished product. The term quality is a broad one and refers to the attributes of a food that make it safe and wholesome, aesthetically attractive, flavorful, convenient, and nutritious for the consumer.

Most of us eat with our perceptive senses rather than on a basis of physiological requirements. However, it is fortunate indeed that the newer developments in food preservation, while perhaps aimed more directly at improving the appeal of the foods to our senses also result in an enhanced retention and stability of vital nutrients. In addition, an ever expanding knowledge of nutritional requirements and food composition, plus advances in chemistry and technology, is pointing the way to improvements in the nutritive value of foods through such devices as fortification and correction of nutrient imbalances. Present and anticipated developments also point the way toward an increasing use of so-called dietary foods and foods compounded to provide special and added nutritional values — as is indicated in the field of geriatric and therapeutic diets.

It has been said that today the average consumer expects and demands better quality and convenience in foods. A significant portion of the increase in income being spent for food can be accounted for in the cost of these services. The food store of today is very different from that of a generation ago. The process has not all been in appearance. Modern processing and packaging of food gives better retention of nutritive value, more sanitary handling conditions and often better retention of color and flavor. The public has come to expect this service as well as constant improvement in quality. Under our economic system competition and public demand make such progress imperative.

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